A patent citation-based perspective to explore the technology life cycle

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Introduction

The ability to analyze and monitor the history and current stage of a particular technology is a critical asset to gain competitive advantage and to identify promising opportunities. Technology often presents different development tracks; therefore, it is necessary to consider the technology life cycle when creating a distinct R&D strategy plan. The technology life cycle comprises a pattern of dynamic characteristics pertaining to technology, in which its innovative and economic outcomes change over time. Nowadays, more and more researchers tend to introduce multiple indicators to measure the technology life cycle. Though such statistical indicators offer a convenient way to make a quick sense of the technological stage, they ignore the technology nature of internal knowledge flow and knowledge overflow. In other words, such traditional indicator-based methods cannot explain the dynamic mechanism of technology evolution and fail to determine inner representation. In this paper, we hold the view that the process of technology evolution can be interpreted through the evolution of patent citation behavior.

Methodology

To some extent, the evolution of citation network is similar to the progress of urbanization. The node could be treated as an individual, and the edge could be designated as the community links. At the beginning, the city is a small village, sparsely populated, where hardly anyone has a relationship with others. Thereafter, many people move to this place, and some close community relationships could be observed. Then, more and more people come in and there is more of a community connection, even though a large number of individuals stay isolated; Finally, the urban population keeps increasing to arrive at a relatively stable level, but strong relationships among individuals form a series of communities that can be merged into some larger components. The schematic diagram is presented as Figure 1.

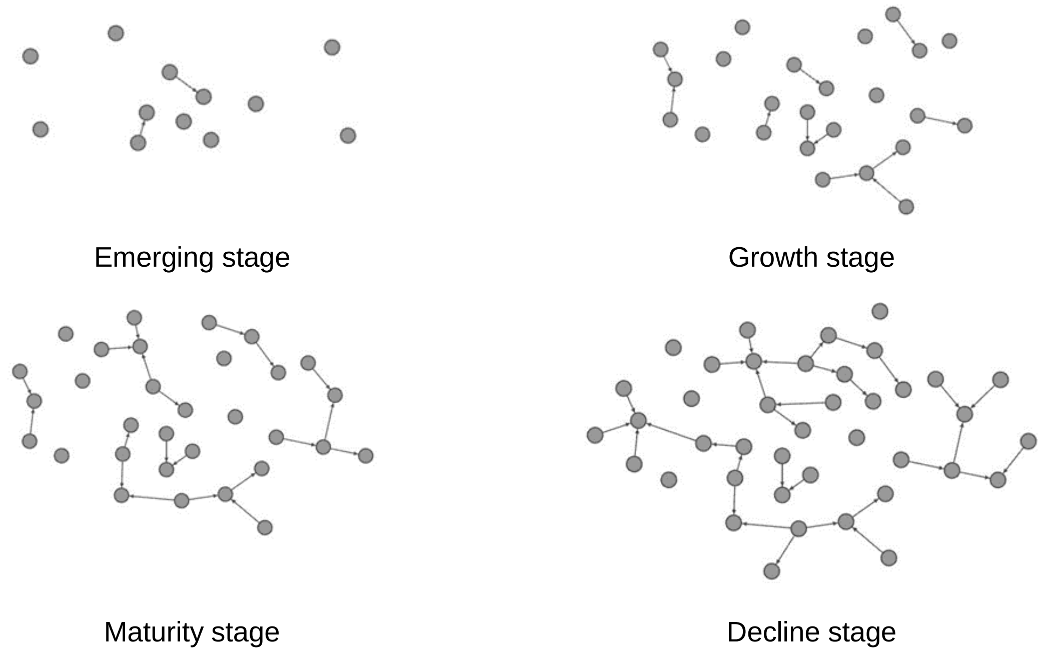

Figure 1. Schematic diagram of community evolution over different life cycle periods

In order to describe these temporal processes, we introduce the growth rate of connected edges and the growth rate of weakly connected components to observe the technology evolution during the development period. Here, connected edge is defined as citation linkage, and the weakly connected component is deemed as the linkage community, among which all nodes are connected. In general, a certain new technology first appears; the rate of activity increases slowly during the emerging stage, and there are various nodes in the technology field. At the growth stage, the technology develops very fast to form some technology focus, among which the nodes are closely linked. In the technology maturity stage, new patents are filed, typically isolated as independent communities, but the number of such nodes grows rapidly. At the decline stage, technology integration becomes a trend or a pattern; citation linkages also become more frequent and some small components merge into larger technology communities. A summary of the technology life cycle's characteristics in relation to the growth rate of connected edges and weakly connected components is provided in Table 1.

Table 1. Characteristics of the technology life cycle periods

Life cycle period	Description
Emerging Stage	Growth rate of connected edges (↑), Growth rate of weakly connected components (↑)
Growth Stage	Growth rate of connected edges (↑↑), Growth rate of weakly connected components (↑)
Maturity Stage	Growth rate of connected edges (↑), Growth rate of weakly connected components (↑↑)
Decline Stage	Growth rate of connected edges (↑↑), Growth rate of weakly connected components (↓)

Brief Results

The proposed approach is applied to additive manufacturing, which give rise to production revolution, stimulate creativity, and decrease our environmental problems. We chose the time span from 1986 to 2015, and the total number of patent families obtained from Thomson Innovation was 16349 (Updated on February 17, 2017). After constructing the citation network by year, we can obtain the information on connected edges and weakly connected components and visualized the indicator information and fit these dots in MATLAB (http://www.mathworks.com/). The results are shown in Figure 2. Based on the analysis, we divide the additive manufacturing development into three stages: emerging (1986-1999), growth (2000-2013), and maturity (2014-now).

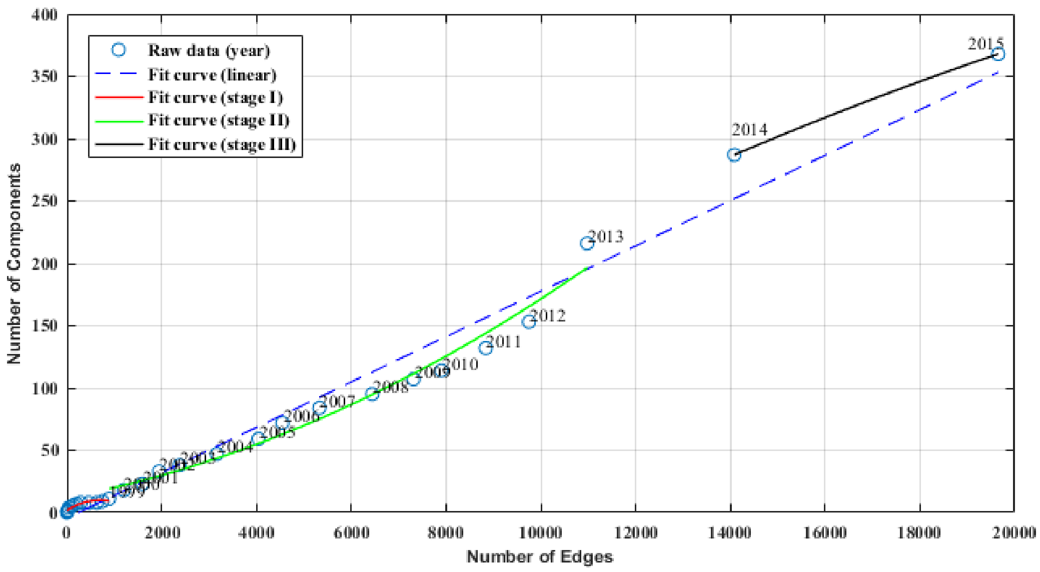

Figure 2. Curve fitting of indicators in the patent citation network of additive manufacturing

Conclusion and Discussion

Tracing technology evolution pathways is essential to track innovation progress, and observing technology changes in different stages can help understand the mainstream track and key technologies. Static technical evolution is only well suited for mature technologies or emerging technologies that are in an extended, stable developmental stage. Compared with previous approach to analyze technology life cycle, the patent citation-based perspective offer a now window to detect the development of technological evolution, which generates technological intelligence that serves to elucidate technological change processes. We believe it can facilitate the identification of innovation opportunities (i.e., prospective paths to commercialization along with target developmental priorities to attain them).

Reference

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